

Fluid Mechanics Cheat Sheet

Properties · hydrostatics · continuity · Bernoulli · energy equation · pipe losses

Fluid properties

Density, specific weight, specific gravity

$$\rho = m/V; \gamma = \rho \cdot g; SG = \rho/\rho_{\text{water}}$$

ρ (kg/m³); γ (N/m³); SG dimensionless

Newtonian shear stress

$$\tau = \mu \cdot du/dy$$

μ dynamic viscosity (Pa·s); du/dy velocity gradient (1/s)

Kinematic viscosity

$$\nu = \mu/\rho$$

ν (m²/s); water at 20 °C is about 1.0×10^{-6} m²/s

Hydrostatics

Pressure with depth

$$P = P_0 + \rho \cdot g \cdot h$$

h depth below the free surface (m); P (Pa)

Gauge and absolute pressure

$$P_{\text{abs}} = P_{\text{gauge}} + P_{\text{atm}}$$

$P_{\text{atm}} = 101.325$ kPa standard

Force on a submerged plane

$$F = \rho \cdot g \cdot h_c \cdot A$$

h_c depth of the area's centroid (m); A area (m²)

Centre of pressure

$$y_p = y_c + I_c/(y_c \cdot A)$$

y measured along the plate from the surface (m); I_c centroidal (m⁴)

Buoyancy (Archimedes)

$$F_B = \rho_{\text{fluid}} \cdot g \cdot V_{\text{displaced}}$$

V displaced volume (m³)

Conservation laws

Continuity (incompressible)

$$Q = A \cdot V; A_1 V_1 = A_2 V_2$$

Q volume flow (m³/s); V mean velocity (m/s)

Bernoulli (along a streamline)

$$P/(\rho g) + V^2/(2g) + z = \text{constant}$$

Steady, incompressible, inviscid, no pump or turbine; each term in m of head

Energy equation (pipe systems)

$$P_1/\gamma + V_1^2/2g + z_1 + h_p = P_2/\gamma + V_2^2/2g + z_2 + h_t + h_L$$

h_p pump head; h_t turbine head; h_L head loss (m)

Momentum (steady control volume)

$$\Sigma F = \rho \cdot Q \cdot (V_{\text{out}} - V_{\text{in}})$$

Vector equation; F (N); one inlet and one outlet

Pump power

$$P_{\text{shaft}} = \rho \cdot g \cdot Q \cdot h_p / \eta$$

η pump efficiency; P (W)

Pipe flow

Reynolds number

$$Re = \rho \cdot V \cdot D / \mu = V \cdot D / \nu$$

D pipe inside diameter (m); laminar below about 2 300 in pipes

Hydraulic diameter

$$D_h = 4A/P_w$$

P_w wetted perimeter (m); for non-circular ducts

Darcy–Weisbach head loss

$$h_L = f \cdot (L/D) \cdot V^2/(2g)$$

f Darcy friction factor; L pipe length (m)

Laminar friction factor

$$f = 64/Re$$

Fully developed laminar flow in a round pipe

Turbulent friction factor (Swamee–Jain)

$$f = 0.25 / [\log_{10}(\epsilon/(3.7D) + 5.74/Re^{0.9})]^2$$

ϵ roughness (m); explicit fit to Colebrook, within a few percent

Minor losses

$$h_m = K \cdot V^2/(2g)$$

K loss coefficient of a fitting, valve or entrance